



TENNESSEE DEPARTMENT OF

EDUCATION
FIRST TO THE TOP

STEM Designers

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
Consultant:	Casey Haugner Wrenn, (615) 532-4879, Casey.Haugner@tn.gov
Course Code:	0849
Prerequisite(s):	None
Credit:	N/A
Grade Level:	8
Graduation Requirement:	N/A
Coursework and Sequence:	This is the third course in the <i>Middle School STEM</i> sequence of coursework.
Aligned Student Organization(s):	Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit http://tn.gov/education/cte/work_based_learning.shtml .
Available Student Industry Certifications:	N/A
Dual Credit or Dual Enrollment Opportunities:	N/A
Teacher Endorsement(s):	001, 013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 101, 121, 122, 123, 124, 125, 126, 127, 128, 129, 157, 210, 211, 212, 213, 214, 230, 232, 233, 400, 401, 402, 413, 414, 415, 416, 417, 418, 440, 470, 477
Required Teacher Certifications/Training:	Teachers who have never taught this course must attend training provided by the Department of Education.
Teacher Resources:	http://www.tn.gov/education/cte/ScienceTechnologyEngineeringMathematics.shtml

Course Description

STEM Designers is a fundamental middle school course that trains students to define problems and methodically answer the question, “*What is the solution?*” Upon completion of this course, proficient students understand that engineering design is a process of developing solutions to problems and challenges in order to meet the needs of society. Students continue to apply the practices for science and engineering learned in *STEM Explorers* and *STEM Innovators*; however, *STEM Designers* places more

emphasis on practices such as using mathematics and computational thinking; designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information. In addition to gaining a deep understanding of the relationship between engineering and design, students who complete this course will learn how both innovation and engineering design result in new technologies that benefit humans. Standards in this course are aligned with Tennessee State Standards in English Language Arts & Literacy in Technical Subjects and Tennessee State Standards in Mathematics.*

Note: Students are expected to use engineering notebooks to document procedures, design ideas, and other notes for all projects throughout the course.

Program of Study Application

This is the third course in the *Middle School STEM* sequence of coursework and prepares students for multiple programs of study in the STEM career cluster. For more information on the benefits and requirements of implementing STEM courses in full, please visit the STEM website at <http://www.tn.gov/education/cte/ScienceTechnologyEngineeringMathematics.shtml>.

Course Standards

Safety

- 1) Accurately read and interpret safety rules, including but not limited to rules published by the National Science Teachers Association (NSTA), rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. (TN Reading 3, 4)
- 2) Identify and explain the intended use of safety equipment available in the classroom. For example, demonstrate how to properly inspect, use, and maintain safe operating procedures with tools and equipment. Incorporate safety procedures and complete safety test with 100 percent accuracy. (TN Reading 3, 4)

Introduction to Engineering

- 3) Research the history of engineering using textbooks, the websites of professional societies, scholarly narratives, and explain how science, technology, and math have influenced its development. Create a timeline of important engineering milestones, noting the influence of science, technology, and math in the timeline. The timeline may be done via PowerPoint, Prezi, poster, or other graphic format. (TN Reading 1; TN Writing 2, 4, 7)
- 4) Research and illustrate the relationship between science, technology, engineering, and math using a flowchart, Venn diagram, or other graphic organizer. Provide an example of a design solution that incorporated at least three of the disciplines and articulate how they each contributed to the design. (TN Reading 1; TN Writing 2, 4)
- 5) Research how engineers in various disciplines (such as civil, mechanical, electrical, chemical, biomedical, computer, agricultural, industrial, and aerospace) benefit society through the products and solutions they design. Write a paper arguing for the discipline that has benefited

society the most. Illustrate the claim with specific products and benefits. (TN Reading 1; TN Writing 1, 4, 7)

Engineering Design Process

- 6) Evaluate an existing engineering design, such as a local bridge or a famous building, providing evidence from exemplars and design rubrics to justify whether the design meets the specified criteria. Create a presentation explaining how the steps of the design process might have been used to create this feat of engineering, citing historical narratives, published interviews with the architects or engineers involved, and other informational resources. The typical steps of the design process include: identify the problem; identify criteria and specify constraints; brainstorm for possible solutions; research and generate ideas; explore alternative solutions; select an approach; write a design proposal, develop a model or prototype; test and evaluate; refine and improve; create or make a product; and communicate results. (TN Reading 3; TN Writing 1, 2, 4)
- 7) Practice exploring alternative solutions in the engineering design process by creating two solutions for an engineering problem. Test each solution and record the test data. Analyze the test data to determine the differences in the quality for the solutions. Write a conclusion that argues which solution is best and explains why. Support the explanation with specific evidence obtained from test results. For example, create a solar vehicle that is designed travel as fast as possible. The two solutions should have a single variable that is changed, for example drive and axle gear ratio, wheel size, or solar panel angle. (TN Reading 1, 3; TN Writing 1, 4, 7, 9; TN Math 8.SP)
- 8) Use the engineering design process and the practices of science and engineering (see specific practices below) to develop a solution for a given engineering challenge. Chronologically document the entire process in an engineering notebook. The engineering notebook should have bound, dated, and numbered pages. Use permanent ink to document notes. For example, design a balsa or basswood bridge that has the best performance ratio, maximum capacity divided by mass of the bridge. Tests can be done of various basic structure designs before creating a final design. This test data should be included in the engineering notebook. A hand or digital sketch should be made of the design. Pictures can be taken throughout the process and included in the engineering notebook. At minimum, address the following science and engineering practices:
 - a. Using mathematics and computational thinking
 - b. Designing solutions
 - c. Engaging in argument from evidence
 - d. Obtaining, evaluating, and communicating information(TN Reading 3; TN Writing 4)

Fundamental Sketching and Engineering Drawing

- 9) Present a two-dimensional design idea using freehand sketching, manual drafting, and computer-aided drafting (such as SketchUp or AutoCad). Designs should be made to scale and include dimensions, labels, and notes. At least one of the designs presented should be an orthographic (multi-view) projection. Use basic dimensioning rules and apply understanding of the use of lines (e.g., object, hidden, center) to inform the design. Sketch principle views of a simple object from the top, bottom, front, back, left side, and right side. For example, create an

orthographic projection of a CO₂ dragster or a floor plan for a home. (TN Reading 3, 4, 7; TN Writing 4; TN Math 8.G)

- 10) Present a 3-D design idea using freehand sketching, manual drafting, and computer-aided drafting (such as SketchUp, SolidWorks, or Inventor). Designs should be made to scale and include dimensions, labels, and notes. Use basic dimensioning rules and apply understanding of the use of lines (e.g., object, hidden, center). *For example, convert the 2-D design in the activity in the previous standard into a 3-D design in the 3-D version of the software used to create the 2-D design.* (TN Reading 3, 4, 7; TN Writing 4; TN Math 8.G)
- 11) Create a scaled model of a design concept. A digital or manual drafting design should be made of this model prior to building or producing the model. For example, create a digital 3-D design of a product and use a 3-D printer to create a physical model of the design. If a 3-D printer is not available, build a model from materials provided in the class. (TN Reading 3, 4, 7; TN Writing 4; TN Math 8.G)

Final Project

- 12) Work in groups to solve a community or school problem by applying the engineering design process and the practices of science and engineering. Build a prototype, if feasible, and write a technical report detailing the problem, the design process used, and the solution proposed. Include an evaluation of the quality of the solution, and give a presentation to the class. Be able to justify the final design solution with supporting evidence from the process, including graphic representations and visual aids as appropriate. (TN Reading 1, 3, 4, 7, 9; TN Writing 2, 5, 6, 7, 8, 9, 10)

Standards Alignment Notes

*References to other standards include:

- TN Reading: [State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 6-8 Students (page 62).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 2, 5, 6, 8, and 10 at the conclusion of the course.
- TN Writing: [State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 6-8 Students (pages 64-66).
 - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 3 at the conclusion of the course.
- TN Math: [State Standards for Mathematics](#); Math Standards for Middle School.
 - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project-based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate mathematical reasoning as applied to specific technical concepts. In

addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.

- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
 - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.